CERTIFICATION OF TRANSLATION

I, ***Eun-Sook Lee***, an employee of Y.P.LEE, MOCK & PARTNERS of Koryo Bldg., 1575-1 Seocho-dong, Seocho-gu, Seoul, Republic of Korea, hereby declare under penalty of perjury that I understand the Korean language and the English language; that I am fully capable of translating from Korean to English and vice versa; and that, to the best of my knowledge and belief, the statement in the English language in the attached translation of ***Korean Patent Application No. 10-2003-0012867*** consisting of 48 pages have the same meanings as the statements in the Korean language in the original document, a copy of which I have examined.

Signed this 12th day of July 2007

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ABSTRACT

[Abstract of the Disclosure]

Provided are a defect management method using a temporary defect management area and a temporary finalized defect management area, and an apparatus and disc therefor. The write once disc is a disc with at least one record layer, the write once disc including a defect management area formed on at least one of a lead-in area and a lead-out area; a temporary defect management area formed on at least one of the lead-in area and the lead-out area, and in which temporary defect information including only information regarding disc defects detected during a recording operation, and temporary defect management information including information for managing the temporary defect information are recorded; and a temporary finalized defect management area formed on at least one of the lead-in area and the lead-out area, and in which temporary finalized defect information including at least one part of temporary defect information recorded in the temporary defect management area, and temporary finalized defect management information including information for managing the temporary finalized defect information are recorded. Accordingly, it is possible to perform disc defect management on a write once disc while effectively using a defect management area of the disc.

[Representative Drawing]

FIG. 4

SPECIFICATION

[Title of the Invention]

APPARATUS AND METHOD FOR MANAGING DEFECT USING TEMPORARY DMA AND TEMPORARY FDMA AND A DISC THEREOF

[Brief Description of the Drawings]

The above and/or other aspects and advantages of the invention will become apparent from the following description of the embodiments, taken in conjunction with the accompanying drawings in which:

FIG. 1 is a block diagram of a recording apparatus according to a preferred embodiment of the present invention;

FIG. 2 illustrates a structure of a disc according to a preferred embodiment of the present invention;

FIG. 3A illustrates a data structure of the disc illustrated in FIG. 2;

FIG. 3B illustrates an example of a temporary defect management area, a temporary finalized defect management area, and a defect management area illustrated in FIG. 3A;

FIG. 4 is a view for explaining a relationship between the temporary defect management area and the temporary finalized defect management area, according to the present invention;

FIGS. 5A and 5C illustrate a data structure of the temporary defect management area, according to an embodiment of the present invention;

FIGS. 6A and 6B illustrate a data structure of the temporary finalized defect management area, according to an embodiment of the present invention;

FIGS. 7A and 7B respectively illustrate data structures of temporary defect management information *TDDS #i* and a copy thereof;

FIG. 8 illustrates a data structure of temporary defect information *TDFL #i*

according to another embodiment of the present invention;

FIG. 9 illustrates diagrams explaining recording of data in a user data area *A* and a spare area *B*, according to a preferred embodiment of the present invention;

FIG. 10 illustrate data structures of temporary defect information *TDFL #1* and *TDFL #2* recorded as illustrated in FIG. 9;

FIG. 11 illustrates a data structure of information regarding defect #i;

FIG. 12 is a flowchart illustrating a disc defect management method according to a preferred embodiment of the present invention; and

FIG. 13 is a flowchart illustrating a defect management method according to another embodiment of the present invention.

[Detailed Description of the Invention]

[Object of the Invention]

[Technical Field of the Invention and Related Art prior to the Invention]

The present invention relates to disc defect management, and more particularly, to a defect management method using a temporary defect management area and a temporary finalized defect management area, and an apparatus and disc therefor.

Disc defect management is the process of rewriting data stored in a user data area of a disc in which a defect exists to a new portion of the disc's data area, thereby compensating for data loss caused by the defect. In general, disc defect management is performed using linear replacement or slipping replacement. In linear replacement, the user data area in which a defect exists is replaced with a spare data area having no defects. In slipping replacement, the user data area with the defect is slipped and the next user data area having no defects is used.

Both linear replacement and slipping replacement are, however, applicable only to discs such as a DVD-RAM/RW, on which data can be repeatedly recorded and recording can be performed using a random access method. In other words, linear replacement and slipping replacement are difficult to be applied to write once discs on which recording is allowed only once. In general, the presence of defects in a disc is

detected by recording data on the disc and confirming whether or not data has been recorded correctly on the disc. However, once data is recorded on a write once disc, it is impossible to overwrite new data and manage defects therein.

After the development of a CD-R and a DVD-R, a high-density write once disc with a recording capacity of several dozen GBs was introduced. This type of disc can be used as a backup disc since it is not expensive and allows random access that enables fast reading operations. However, disc defect management is not available for write once discs. Therefore, a backup operation may be discontinued when a defective area, i.e., an area where a defect exists, is detected during the backup operation. In general, a backup operation is performed when a system is not frequently used, e.g., at night when a system manager does not operate the system. In this case, it is more likely that the backup operation will be discontinued when because a defective area of a write once disc is detected.

[Technical Goal of the Invention]

The present invention provides a write once disc, and a disc defect management method and apparatus applicable to the write once disc.

The present invention also provides a disc in which disc defect management can be performed even when a disc defect is detected during a recording operation, thus allowing the recording operation to be performed without interruption, and a disc defect management method and apparatus therefor.

The present invention also provides a disc in which defect information can be effectively recorded, and a disc defect management method and apparatus therefor.

[Structure and Operation of the Invention]

According to an aspect of the present invention, there is provided a write once disc with at least one record layer on which a lead-in area, a data area, and a lead-out area are sequentially arranged, the write once disc including a defect management area formed on at least one of the lead-in area and the lead-out area; a temporary defect

management area formed on at least one of the lead-in area and the lead-out area; and a temporary finalized defect management area formed on at least one of the lead-in area and the lead-out area, wherein the temporary defect management area is an area in which temporary defect information including only information regarding disc defects generated in the corresponding recording operation, and temporary defect management information including information for managing the temporary defect information are recorded, and the temporary defect information and the temporary defect management information are recorded in predetermined units as pairs of information.

The temporary finalized defect management area is an area in which temporary finalized defect information including at least one of temporary defect information recorded in the temporary defect management area, and temporary finalized defect management information including information for managing the temporary finalized defect information are recorded.

The defect management area is an area in which the recorded temporary defect information and temporary defect management information are respectively recorded as defect information and defect management information, when finalizing.

The temporary defect management area includes a plurality of areas, and the temporary defect information and the temporary defect management are recorded several times in the plurality of areas.

According to another aspect of the present invention, there is provided a method of managing disc defects, the method including: (a) recording only temporary defect information regarding a defect detected in data, which is recorded in a data area of a disc during a first recording operation, and temporary management information including the temporary defect management information, as first temporary defect information, in units of a predetermined number of blocks, in a temporary defect management area; (b) repeating (a) and (b) at least once while increasing indexes given to the recording operation and the temporary management information by 1; (c) recording temporary finalized management information obtained on the basis of the recorded temporary management information whenever the first temporary

management information is recorded k times, in a temporary finalized defect management area; (d) repeating (a) through (c) at least once; and (e) reading and writing all of recorded temporary defect management information and temporary defect information in a defect management area (k is an integer equal to or greater than 2).

The temporary defect management area includes a plurality of area, and in operation (a), the temporary defect information and the temporary defect management information are respectively recorded several times in the plurality of areas.

Meanwhile, according to still another aspect of the present invention, there is provided a recording apparatus comprising a recording/reading unit that records data on or reads data from a disc; and a controller that controls the recording/reading unit to record temporary defect information regarding a defect detected from data, which is recorded in a data area of the disc according to a recording operation, and temporary management information including the temporary defect management information, in units of a predetermined number of blocks, in a temporary defect management area, and to record temporary finalized management information obtained on the basis of the temporary defect management information recorded in the temporary defect management area whenever the temporary management information is recorded k times, in a temporary finalized defect management area, wherein k is an integer equal to or greater than 2.

The temporary defect management area includes a plurality of areas, and the controller controls the recording/reading unit so that the temporary management information is repeatedly recorded several times in the plurality of areas.

Hereinafter, embodiments of the present invention will be described in detail with reference to the appended drawings.

FIG. 1 is a block diagram of a recording apparatus according to a preferred embodiment of the present invention. Referring to FIG. 1, the recording apparatus includes a recording/reading unit 1, a controller 2, and a memory 3. The recording/reading unit 1 records data on a disc 100, which is an information storage medium according to a preferred embodiment of the present invention, and reads back

the data from the disc 100 to verify the accuracy of the recorded data. The controller 2 performs disc defect management according to the present invention. In this embodiment, the controller 2 uses a verify-after-write method in which data is recorded on the disc 100 in predetermined units of data and the accuracy of the recorded data is verified to detect if an area of the disc 100 has a defect. In other words, the controller 2 records user data on the disc 100 in units of recording operations and verifies the recorded user data to detect an area of the disc 100 in which a defect exists. Thereafter, the controller 2 creates information indicating the position of the area with the defect and stores the created information in the memory 3. When the amount of the stored information reaches a predetermined level, the controller 2 records the stored information as temporary defect information on the disc 100.

Here, the recording operation is an operation unit determined according to a user's intention or a recording work to be performed. According to this embodiment, a recording operation indicates a process in which the disc 100 is loaded into the recording apparatus, data is recorded on the disc 100, and the disc 100 is taken out from the recording apparatus. During the recording operation, data is recorded and verified at least once; in general, data is recorded and verified several times. Defect information obtained using the verify-after-write method is temporarily stored as temporary defect information in the memory 3.

When a user presses the eject button (not shown) of the recording apparatus in order to remove the disc 100 after recording of data, the controller 2 expects the recording operation to be terminated. Next, the controller 2 reads the information from the memory 3, provides it to the recording/reading unit 1, and controls the recording/reading unit 1 to record it on the disc 100. In this case, the defect information is recorded as the temporary defect information on the disc 100 in recording operation units. Here, recoding the defect information in the recording operation units must be understood as recording information regarding a defect detected during only a corresponding recording operation unit.

When the recording of data is completed, i.e., additional data will not be recorded

on the disc 100 (the disc 100 needs to be finalized), the controller 2 controls the recording/reading unit 1 to rewrite temporary defect information and temporary defect management information, which is stored in the disc 100, as defect management information to a defect management area (DMA) of the disc 100.

FIG. 2 illustrates structures of the disc 100 of FIG. 1 according to preferred embodiments of the present invention. (a) of FIG. 2 illustrates in detail a single record layer disc representation of disc 100 having a record layer *L0*. The disc 100 includes a lead-in area, a data area, and a lead-out area. The lead-in area is located in an inner part of the disc 100 and the lead-out area is located in an outer part of the disc 100. The data area is present between the lead-in area and the lead-out area and divided into a user data area and a spare area.

The user data area is an area where user data is recorded, and the spare area is a replacement area for a user data area having a defect, serving to compensate for loss in the recording area due to the defect. On the assumption that defects may occur within the disc 100, it is preferable that the spare area assumes about 5% of the entire data capacity of the disc 100, so that a greater amount of data can be recorded on the disc 100.

(b) of FIG. 2 illustrates a double record layer disc representation of disc 100 having two record layers *L0* and *L1*. A lead-in area, a data area, and an outer area are sequentially formed from the inner part of the first record layer *L0* to its outer part. Also, an outer area, a data area, and a lead-out area are sequentially formed from the outer part of the second record layer *L1* to its inner part. Unlike the single record layer disc of FIG. 2A, the lead-out area is present in the inner part of the disc 100 of FIG. 2B. That is, the disc 100 of FIG. 2B has an opposite track path (OTP) in which data is recorded starting from the lead-in area of the first record layer *L0* toward its outer area and continuing from the outer area of the second record layer *L1* to its lead-out area. The spare area is allotted to each of the record layers *L0* and *L1*.

In this embodiment, the spare areas are present between the lead-in area and the user data area and between the user data area and the outer area. However, if

necessary, a portion of the user data area may be used as another spare area, that is, more than one spare area may be present between the lead-in area and the lead-out area. However, the positions of the spare areas are not limited to this finalized.

FIG. 3A illustrates a data structure of the disc 100 of FIG. 2 according to a first embodiment of the present invention. Referring to FIG. 3A, if the disc 100 is a single record layer disc, a defect management area (DMA) and a temporary DMA (TDMA) are formed in a lead-in area. Alternatively, the DMA may be included in both the lead-in area and a lead-out area, or the TDMA may also be included in the lead-out area. That is, the DMA and the TDMA may be present in at least one of the lead-in area and the lead-out area. If the disc 100 is a double record layer disc, the DMA and the TDMA are respectively present in a lead-in area and a lead-out area located at an inner part of the disc 100. The DMA may further be included in the lead-out area and an outer area that are located at an outer part of the disc 100. Accordingly, the DMA and the TDMA are present in at least one of the lead-in area, the lead-out area, and the outer area.

In general, information relating to managing disc defects in the disc 100 is recorded in the DMA. Such information specifies or includes the structure of the disc 100 for disc defect management, whether the disc defect management is performed or not, defect information, the location of the defect information, and the position and size of a spare area. In this embodiment, because the disc 100 is a write once disc, new data is recorded after previously recorded data when the above information changes.

In general, when a disc is loaded into a recording/reading apparatus, the apparatus reads data from a lead-in area and a lead-out area of the disc to determine how to manage the disc and record data on or read data from the disc. However, if the amount of data recorded in the lead-in area and/or the lead-out area increases, a longer time is spent on preparing the recording or reproducing of data after the loading of the disc. To solve this problem, the present invention uses temporary defect management information and temporary defect information that are to be recorded in a TDMA. The TDMA is allotted to the lead-in area and/or the lead-out area of a disc, being separated from the DMA. That is, only lastly recorded defect information and defect management

information, which are required to perform disc defect management, are recorded in the DMA, thereby reducing the amount of information that the recording/reading unit requires for a recording/reproducing operation.

In this embodiment, since disc defect management is performed using linear replacement, the temporary defect information includes information indicating the position of an area of the disc 100 having a defect and information indicating the position of an area of the disc 100 that is replacement for the area having the defect. More preferably, the temporary defect information further includes information indicating whether the defect occurs in a single defect block or physically continuous defect blocks. The temporary defect management information is used to manage the temporary defect information and includes information indicating the location of the temporary defect information recorded on the disc 100. Detailed data structures of temporary defect information and temporary defect management information will be explained later.

In this embodiment, the temporary defect information and temporary defect management information are recorded every time when a recording operation ends. In the TDMA, information regarding a defect occurring in data recorded during a recording operation #0 and information regarding its replacement are recorded as temporary defect information #0, and information regarding a defect occurring in data recorded during a recording operation #1 and information regarding its replacement are recorded as temporary defect information #1. Further, management information for managing temporary defect information #0, #1, ... is recorded as temporary defect management information #0, #1, ... in the TDMA, the management information specifying the recording locations of the temporary defect information #0, #1, ... When additional data cannot be recorded in the data area or a user does not wish to record additional data therein, i.e., disc finalization is required, temporary defect information and temporary defect management information recorded in the TDMA are rewritten to the DMA.

The temporary defect information and the temporary defect management information are rewritten to the DMA for the following reasons. In the case that

additional data will not be recorded on the disc 100, i.e., the disc 100 needs to be finalized, only last recorded ones of the temporary defect management information and temporary defect information, which have been updated several times, are again recorded in the DMA. Thus, the recording/reading unit 1 can fast read defect management information from the disc 100 just by reading the last recorded defect management information, thereby enabling fast initializing of the disc 100. Further, recording of the temporary defect information and temporary defect management information in the DMA increases the reliability of information.

In this embodiment, defect information contained in previously recorded temporary defect information #0, #1, #2,..., and #i-1 is not included in the temporary defect information *#i*. That is, only information regarding a defect detected from a recording area during a corresponding recording operation *#i* is included in the temporary defect information *#i*. For instance, the temporary defect information #0 specifies a defect detected during a recording operation #0, and the temporary defect information #1 specifies only a defect detected during a recording operation #1. Accordingly, it is possible to effectively use a recording area of the TDMA. In other words, the recording area of the lead-in area (or the lead-out area or the outer area) including the TDMA is very smaller than a data area where user data is recorded. Nevertheless, if information regarding a defect detected whenever a recording operation is performed is recorded to include all of information regarding defects detected during previous recording operations, data may not be further recorded in the TDMA before the data area is full of data. For this reason, in this embodiment, temporary defect information includes only information regarding a defect detected during a related recording operation. Instead, during disc finalization, all defect information included in the temporary defect information #0, #1, #2, ..., #i is read and written to the DMA.

In the case of a high-density disc with a recording capacity of several dozens of GBs, it is desirable that a cluster is allocated to an area in which temporary defect management information #i is recorded and four to eight clusters are allocated to an area in which temporary defect information #i is recorded. This is because it is

preferable to record new information in units of clusters to update information when a minimum physical unit of record is a cluster, although the amount of temporary defect information #i is just several KBs. A total amount of defects allowed in a disc is preferably about 5 percentage of the disc recording capacity. For instance, about four to eight clusters are required to record temporary defect information #i, considering that information regarding a defect is about 8 bytes long and the size of a cluster is 64 KBs long.

The verify-after-write method can also be performed on temporary defect information #i and temporary defect management information #i. When a defect is detected, information recorded in an area of a disc having a defect may be either recorded in a spare area using linear replacement, or recorded in an area adjacent to the TDMA using slipping replacement.

FIG. 3B illustrates a data structure of a disc with a TDMA and DMAs shown in FIG. 3A. Referring to FIG. 3B, two DMAs, i.e., DMA #1 and DMA #2, are formed to increase the robustness of defect management information and defect information. *TDMA* denotes a temporary defect management area; *Test* denotes an area in which recording conditions of data are measured; *Drive and Disc information* is an area in which information regarding a drive used during a recording and/or reproducing operation(s) and disc information are recorded; and *Buffer 1*, *Buffer 2*, and *Buffer 3* are buffers indicating borders of the respective areas.

FIG. 4 is a view for explaining a relationship between the temporary defect management area and the temporary finalized defect management area, according to the present invention.

Referring to FIG. 4, if temporary management information including temporary defect information and temporary defect management information is recorded predetermined times in the TDMA, the recorded temporary management information is collected and recorded as temporary finalized management information in the temporary finalized defect management area. That is, if temporary management information TDMA #1, #2, ..., #k are recorded k times in the temporary defect

management area, the recorded temporary management information TDMA #1, #2, ..., #k are finalized and recorded as temporary finalized management information TFDMA #1 in the TDMA. If temporary management information TDMA #k+1, ..., #2k are again recorded k times in the TDMA, the recorded temporary management information TDMA #k+1, ..., #2k are collected, finalized, and then recorded as temporary finalized management information TFDMA #2 in the temporary finalized defect management area.

The temporary finalized management information TDMA #1 includes the temporary defect information of the temporary management information TDMA #1, #2, ..., #k*n, and information regarding a location at which next temporary management information TDMA #k*n+1 is to be recorded. Accordingly, the recording or reproducing apparatus reads temporary defect information contained in the temporary finalized management information finally in the temporary finalized management area even before finalizing, and reads the remaining temporary defect information from next temporary management information recorded in the temporary defect management area with reference to information regarding a location in which the next temporary management information contained in the finally recorded temporary finalized management information is to be recorded, thereby more quickly detecting defect information than when no temporary finalized management information is recorded.

FIGS. 5A and 5C illustrate a data structure of the temporary defect management area, according to an embodiment of the present invention;

FIG. 5A illustrates a data structure of temporary management information TDMA according to an embodiment of the present invention. Referring to FIG. 4A, corresponding temporary defect information and temporary defect management information are recorded as a pair of information in the TDMA. More specifically, temporary management information *TDMA #1, TDMA #2* are sequentially recorded starting from the start of the TDMA. A pair of corresponding temporary defect management *TDDS #1* and temporary defect information *TDFL #1* are included twice in the temporary management information *TDMA #1*. A pair of corresponding temporary

defect management information *TDDS #2* and temporary defect information *TDFL #2* are included twice in temporary management information *TDMA #2*. A reason for recording the same information twice is to increase the reliability and robustness of the information. The location information of the corresponding temporary defect information *TDFL #1, #2, ..* is respectively recorded in the temporary defect management information TDMA #1, #2, ... Each temporary defect management information further specifies the location of temporary defect information recorded right before its corresponding temporary defect information. For instance, the temporary management information *TDMA #2* sequentially includes a pair of the temporary defect information *TDFL #2* and temporary defect management information *TDDS #2*, and a copy of the temporary defect information *TDFL #2* and temporary defect management information *TDDS #2*. The temporary defect management information *TDDS #2* contains location information regarding the temporary defect information *TDFL #2* and a copy of temporary defect information *TDFL #1* recorded right before the temporary defect information *TDFL #2*. The copy of the temporary defect management information *TDDS #2* contains location information regarding its corresponding copy of the temporary defect information *TDFL #2*, and location information regarding the temporary defect information *TDFL #2*. As described above, if temporary defect management information further specifies the location of temporary defect information recorded right before corresponding temporary defect information, it is possible to more rapidly read all recorded temporary defect information than where temporary defect information is accumulatively recorded. The number of recording the temporary defect management information *TDDS #1, #2* and the temporary defect information *TDFL #1, #2* is not limited.

FIG. 5B illustrates a data structure of a TDMA according to another embodiment of the present invention.

Referring to FIG. 5B, compared to the TDMA of FIG. 5A, corresponding temporary defect information and temporary defect management information are recorded as pairs of information in the TDMA, but the sequence of recording the

information is not the same. More specifically, temporary management information *TDMA #1, #2, ...* is sequentially recorded starting from the end of the TDMA. A pair of corresponding temporary defect management *TDDS #1* and temporary defect information *TDFL #1* are included twice in the temporary management information *TDMA #1*. A pair of corresponding temporary defect management information *TDDS #2* and temporary defect information *TDFL #2* are included twice in temporary management information *TDMA #2*, thereby increasing the reliability and robustness of the information. The temporary defect management information *TDDS #1, #2, ...* specifies the locations of their corresponding temporary defect information *TDFL #1, #2, ...*, respectively. Each temporary defect management information further specifies the location of the temporary defect information recorded right before its corresponding temporary defect information. For instance, the temporary management information *TDMA #2* sequentially includes a pair of the temporary defect information *TDFL #2* and the temporary defect management information *TDDS #2*, and a copy of the temporary defect information *TDFL #2* and the temporary defect management information *TDDS #2*. Also, the temporary defect management information *TDDS #2* contains location information regarding the temporary defect information *TDFL #2* and a copy of the temporary defect information *TDFL #1* recorded right before the temporary defect information *TDFL #2*. The copy of the temporary defect management information *TDDS #2* contains location information regarding its corresponding copy of the temporary defect information *TDFL #2*, and the location information regarding temporary defect management information *TDFL #2*.

FIG. 5C illustrates another example of a data structure of the temporary defect management area.

Referring to FIG. 5C, like the cases of FIGS. 5A and 5C, corresponding temporary defect information and temporary defect management information are recorded twice as pairs of information, and the pairs of information are respectively recorded in different areas. That is, the temporary defect management area TDMA is divided into two areas of TDMA #i and copy of TDMA #i, and the areas of TDMA #i and

copy of TDMA #i are respectively recorded in different areas. Meanwhile, in this specification, the temporary defect management area is divided into two areas, and the same temporary management information is repeatedly recorded twice in the two areas. Also, it is possible that the temporary defect management area is divided into two or more areas, and the same temporary management information is repeatedly recorded several times in the two or more areas.

Meanwhile, as illustrated in FIGS. 5A through 5C, when temporary defect information and the corresponding temporary defect management information constructing the temporary management information TDMA #i are recorded in the temporary defect management area, the temporary defect information and the corresponding temporary defect management information can be recorded as pairs of information, in a recording unit, wherein the recording unit consists of a predetermined number of blocks. In other words, TDFL #2 and TDDS #2 constructing TDMA #2 are recorded in a predetermined number of blocks, for example, in the same block. Likewise, TDFL #2 COPY and TDDS #2 COPY are recorded in the same block.

As such, temporary defect information and the corresponding temporary defect management information are together recorded as a pair of information, in a predetermined number of block, so that the size of an area in which a pair of temporary management information are recorded becomes uniform and access to temporary management information is facilitated.

FIGS. 6A through 6D illustrate a data structure of a temporary finalized defect management area according to an embodiment of the present invention.

FIG. 6A illustrates an example of a data structure of a temporary finalized defect finalized area.

Referring to FIG. 6A, temporary finalized management information TFDMA #1, TFDMA #2, .., TFDMA #n are sequentially recorded in the temporary finalized defect management area TFDMA, starting from the start of the temporary finalized defect management area. Corresponding temporary finalized defect management information TFDDS #n and temporary finalized defect information TFDFL #n are

respectively recorded twice in an arbitrary temporary finalized management information TFDMA #n, thereby improving the reliability and robustness of information. corresponding temporary finalized defect information TFDFL #n is recorded in the temporary finalized defect management information TFDDS #n. Furthermore, information indicating the location of final temporary defect information recorded in corresponding temporary finalized defect information TFDFL #n, that is, location information of temporary management information TDMA #k*n+1 which will be next recorded when temporary finalized defect management information TFDDS #n is recorded after temporary management information is recorded k times, is recorded in the temporary finalized defect management information TFDDS #n.

Meanwhile, the number of recording the temporary finalized defect management information *TFDDS #n* and the temporary finalized defect information *TFDFL #n* is not limited.

FIG. 6B illustrates an example of FIG. 6A.

Referring to FIG. 6B, if temporary finalized management information TFDMA #1, #2, ..., #n is respectively recorded whenever temporary management information TDMA is recorded k times, the recorded temporary defect information TDFL #1, #2, ..., #k*n are all accumulated and recorded in the temporary finalized defect information TFDFL #n. Temporary finalized defect management information TFDDS #n includes a pointer indicating the location of the corresponding temporary finalized defect information TFDFL #n, and a pointer indicating the location of temporary management information TDMA #k*n+1 which will be next recorded, wherein k is an integer equal to or greater than 2.

FIG. 6C illustrates another example of a data structure of the temporary defect management area.

Referring to FIG. 6C, information is recorded in the same way as described above with reference to FIG. 6A, but the recording positions of information are not the same. That is, temporary finalized management information TFDMA #1,TFDMA #2, ..., TFDMA #n are sequentially recorded in a temporary finalized defect management area,

starting from the end of the temporary finalized defect management area. Corresponding temporary finalized defect management information TFDDS #n and temporary finalized defect information TFDFL #n are respective recorded twice in an arbitrary temporary finalized management information TFDMA #n, thereby improving the reliability and robustness of information. The location information of the corresponding temporary finalized defect information TFDFL #n is recorded in the temporary finalized defect management information TFDDS #n. Furthermore, information indicating the location of final temporary defect information recorded in corresponding temporary finalized defect information TFDFL #n, that is, location information of temporary management information TDMA #k*n+1 which will be next recorded when temporary finalized defect management information TFDDS #n is recorded after temporary management information is recorded k times, is recorded in the temporary finalized defect management information TFDDS #n, wherein k is an integer equal to or greater than 2.

Meanwhile, the number of recording the temporary finalized defect management information *TFDDS #n* and the temporary finalized defect information *TFDFL #n* is not limited.

FIG. 6D is an example of FIG. 6C.

Referring to FIG. 6D, if temporary finalized management information TFDMA #1, #2, ..., #n is respectively recorded whenever temporary management information TDMA is recorded k times, the recorded temporary defect information TDFL #1, #2, ..., #k*n are all accumulated and recorded in the temporary finalized defect information TFDFL #n. Temporary finalized defect management information TFDDS #n includes a pointer indicating the location of the corresponding temporary finalized defect information TFDFL #n, and a pointer indicating the location of temporary management information TDMA #k*n+1 which will be next recorded, wherein k is an integer equal to or greater than 2.

FIG. 7A illustrates a data structure of temporary defect management information *TDDS #i*.

Referring to FIG. 7A, the temporary defect management information *TDDS #i* includes an identifier for the temporary defect management information *TDDS #i*, a pointer to the recording position of a copy of temporary defect information *TDFL #i-1* recorded right before corresponding temporary defect information *TDFL #i*, and a pointer to the recording position of the temporary defect information *TDFL #i*.

FIG. 7B illustrates a data structure of a copy of temporary defect management information *TDDS #i*.

Referring to FIG. 7B, the copy of temporary defect management information *TDDS #i* contains an identifier for the copy of the temporary defect management information *TDDS #i*, a pointer to the recording position of the temporary defect information *TDFL #i* recorded in the temporary defect management information *TDDS #i*, and a pointer to the recording position of a copy of the temporary defect information *TDFL #i*.

FIG. 8 illustrates a data structure of temporary defect information *TDFL #i*. Referring to FIG. 8, temporary defect information *TDFL #i* contains an identifier for the temporary detect information *TDFL #i*, and information regarding a defect detected during a corresponding recording operation #i. That is, information regarding defects detected during previous recording operations #0, #1, ..., #i-1 is not included in the temporary defect information *TDFL #i*. Here, the information regarding a defect indicates the positions of the defect and its replacement and whether the defect occurs in a single defect block or continuous defect blocks. A detailed data structure of information regarding disc defects will be described later.

FIG. 9 is a reference diagram illustrating in detail recording of data in a user data area *A* and a spare area *B*, according to a preferred embodiment of the present invention.

Data can be processed in units of sectors or clusters. A sector denotes a minimum unit of data that can be managed in a file system of a computer or in an application. A cluster denotes a minimum unit of data that can be physically recorded on a disc at once. In general, one or more sectors constitute a cluster.

There are two types of sectors: a physical sector and a logical sector. The physical sector is an area on a disc where a sector of data is to be recorded. An address for detecting the physical sector is called a physical sector number (PSN). The logical sector is a unit in which data can be managed in a file system or an application. An address for detecting the logical sector is called a logical sector number (LSN). A disc recording/reading apparatus detects the recording position of data on a disc using a PSN. In a computer or an application relating to data, the entire data is managed in units of LSNs and the position of data is detected using an LSN. LSNs and PSNs are mapped by a controller of the recording/reading apparatus, based on whether the disc contains a defect and an initial recording position of data.

Referring to FIG. 9, *A* denotes a user data area and *B* denotes a spare area in which PSNs are sequentially allocated to a plurality of sectors (not shown). In general, each LSN corresponds to at least one PSN. However, since LSNs are allocated to non-defective areas, including replacements recorded in the spare area, the correspondence between the PSNs and the LSNs is not maintained when a disc has a defective area, even if the size of a physical sector is the same as that of a logical sector.

In the user data area *A*, user data is recorded either in a continuous recording mode or a random recording mode. In the continuous recording mode, user data is recorded sequentially and continuously. In the random recording mode, user data is randomly recorded. In the data area *A*, sections ① through ⑦ denote predetermined units of data in which the verify-after-write method is performed. A recording apparatus records user data in section ①, returns to the start of section ①, and checks if the user data is appropriately recorded or a defect exists in section ①. If a defect is detected in a portion of section ①, the portion is designated as defect #1. The user data recorded in defect #1 is also recorded on a portion of the spare area *B*. Here, the portion of the spare area *B* in which data recorded in defect #1 is rewritten is called replacement #1. Next, the recording apparatus records user data in section ②,

returns to the start of section ②, and checks whether the data is properly recorded or a defect exists in section ②. If a defect is detected in a portion of section ②, the portion is designated as defect #2. Likewise, replacement #2 corresponding to defect #2 is formed in the spare area *B*. Further, defect #3 and replacement #3 are designated in section ③ of the user data area *A* and the spare area *B*, respectively. In section ④, a defect does not occur and a defective area is not designated.

The recording apparatus records information regarding defect #1, #2, and #3 occurring in sections ① through ④ as temporary defect information *TDFL #1* in a TDMA, when recording operation #1 is expected to end, after the recording and verifying of data to section ④, i.e., when a user presses the eject button of a recording apparatus or recording of user data allocated in a recording operation is complete. Also, management information for managing temporary defect information *TDFL #1* is recorded as temporary defect management information *TDDS #1* in the TDMA.

When recording operation #2 starts, data is recorded in sections ⑤ through ⑦ and defects #4 and #5 and replacements #4 and #5 are formed. If the second recording operation #2 is expected to end, the recording apparatus records information regarding defects #4 and #5 as temporary defect information *TDFL #2*. , Likewise, defect management information for managing the TDFL #2 is recorded as TDDS #2 in the temporary defect management area.

FIG. 10 illustrates data structures of temporary defect information *TDFL #1* and *#2* recorded as explained with respect to FIG. 9.

Referring to FIG. 10, the temporary defect information *TDFL #1* describes defects detected during a recording operation #1. That is, the temporary defect information *TDFL #1* contains information regarding defects #1, #2, and #3. The information regarding defect #1 indicates the position of an area in which defect #1 exists and the position of an area in which replacement #1 is recorded. The information regarding defect #2 indicates the position of an area in which defect #2 exists, and the position of an area in which replacement #2 is recorded. The

information regarding defect #3 the position of an area in which defect #3 exists, and the position of an area in which replacement #3 is recorded.

Temporary defect information *TDFL #2* describes only defects detected during a recording operation #1. That is, the temporary defect information *TDFL #1* contains information regarding defects #4 and #5.

FIG. 11 illustrates a data structure of information regarding a defect #i according to a preferred embodiment of the present invention.

Referring to FIG. 11, the information regarding a defect #i describes a pointer to the defect #i and a pointer to a corresponding replacement #i. Further, the information regarding the defect #i may further include state information that indicates whether the defect #i occurs in continuous defect blocks or a single defect block. The inclusion of the state information into the information regarding the defect #i is optional. If the defect #i occurs in the continuous defect blocks, the state information further represents whether the pointer for defect #i points to the start or end of the continuous defect blocks and whether the pointer for replacement #i points to the start or end of a replacement block that replaces defect #i. When the state information indicates the pointer for defect #i as the start of the continuous defect blocks and the pointer for replacement #i as the start of the replacement block, the pointer for defect #i represents a starting physical sector number of the continuous defect blocks and the pointer for replacement #i represent a starting physical sector number of replacement #i. In contrast, when the state information indicates the pointer for defect #i as the end of the continuous defect blocks and the pointer for replacement #i as the end of the replacement block, the pointer for defect #i represents an ending physical sector number of the continuous defect blocks and the pointer for replacement #i represent an ending physical sector number of replacement #i. The definition of at least two continuous defect blocks where defects exist using state information enables effectively recording of information and saves a space of recording, even if information regarding defects is not recorded in units of blocks. Here, the block denotes a logical record unit of data.

The pointer for defect #i specifies a starting and/or ending point(s) of defect #i. The pointer for defect #i may include a starting PSN of defect #i. The pointer for replacement #i specifies a starting and/or ending points of replacement #i. The pointer for replacement #i may also include a starting PSN of replacement #i.

Hereinafter, preferred embodiments of a disc defect management method according to the present invention using the recording unit 1 of FIG. 1 and the disc 100 according to the first embodiment of the present invention, will be described with reference to the accompanying drawings.

FIG. 12 is a flowchart illustrating a disc defect management method according to a first embodiment of the present invention.

Referring to FIG. 12, the recording apparatus sets n to 1 (operation 1201), and records only defect information for data recorded according to a n-th recording operation, as n-th temporary defect information, in a temporary defect management area, in order to manage disc defects (operation 1202). Also, management information for managing the n-th temporary defect information is recorded as the n-th defect management information in the temporary defect management area (operation 1203).

Before finalizing is performed (operation 1204), operations 1202 and 1203 are repeated while increasing n by 1 until n becomes a multiple of k (operation 1208). If n becomes a multiple of k (operation 1205), the recorded temporary defect information is all collected and recorded as a n/k-th temporary finalized defect information in the temporary finalized defect management area (operation 1206), n/k-th temporary finalized defect management information including information for managing the n/k-th temporary finalized defect information, and information indicating a location which the next temporary defect information (and/or temporary defect management information) will be recorded, is recorded in the temporary finalized defect management area (operation 1207), and the above operations are repeated while increasing n by 1 until n becomes a multiple of k before finalizing is again performed.

If finalizing is performed (operation 1204), the recorded temporary defect management information and temporary defect information are read from the temporary

finalized defect management area and the temporary defect management area, and recorded in the defect management area (operation 1209). In more detail, temporary defect information included in temporary finalized management information finally recorded in the temporary finalized management area is all read, and the location of the remaining temporary defect information recorded in the temporary defect management area is detected from the temporary finalized management information, thereby reading the remaining temporary defect information. Thus, the recorded temporary defect management information and temporary defect information are simultaneously recorded as final defect management information and final defect information in the defect management area. The final defect information and the final defect management information can be repeatedly recorded in order to improve the reliability of data recording. Also, if a defect is found in the final defect information and the final defect management information upon verification after recoding, all data recorded after a part in which the defect is found is neglected (the all data is designated to a defective area), and then the remaining final defect information and final defect management information are recorded after the defective area is designated.

FIG. 13 is a flowchart illustrating a disc defect management method according to a second embodiment of the present invention.

Referring to FIG. 13, the recording apparatus sets n to 1 (operation 1301), and records user data in a data area when verification is performed after recording (operation 1302). Then, data recorded in operation 1301 is verified and a part in which a defect is generated is detected (operation 1303). The controller 2 designates the part in which the defect is generated to a defective area, again records data recorded in the defective area in a spare area to generate a replacement area, generates pointer information indicating the part in which the defect is generated and the replacement area (operation 1304), and then stores the pointer information as temporary defect information in the memory 3 (operation 1305). Here, state information representing whether the defective area is a single defect block or successive defective blocks, is further generated, and the state information can be also stored as temporary defect

information. Before the recording operation is expected to end (operation 1306), operations 1302 through 1305 are repeated.

If user data recording is complete according to a user's input or a recording operation and the recording operation is expected to end (operation 1306), the controller of the recording apparatus reads temporary defect information stored in the memory 3, records the temporary defect information as temporary defect information TDFL #1 in the temporary defect management area (operation 1307), and records temporary defect management information TDDS #1 as management information for managing the TDFL #1, twice (operation 1308). Here, the number of data recording can vary. Operations 1302 through 1308 are repeated while increasing n by 1 (operation 1313) until finalizing is performed (operation 1309). Whenever operations 1302 through 1308 operate, indexes added to the TDFL and TDDS are increased by 1 (operation 1314). The temporary defect information TDFL #i records only information regarding a defect generated in the corresponding recording operation #I, and does not record information regarding a defect generated in the previous recording operations #1, #2, ..., #i-1.

If n becomes a multiple of k (operation 1310) before finalizing is performed (operation 1309), the recorded TDFL is collected, finalized, and recorded as temporary finalized defect information TFDFL #1 (operation 1311), and TFDDS #1 containing information for managing TFDFL #1 and information indicating a location in which the next temporary defect information TDFL (and/or temporary defect management information TDDS) is recorded, is recorded (operation 1312). Whenever n becomes a multiple of k (operation 1310) until finalizing is performed (operation 1309), operations 1311 and 1312 are repeated while increasing indexes added to the TFDFL and TFDDS by 1 (operation 1314).

If finalizing is performed (operation 1309), the recorded temporary defect information and the temporary defect management information are all read from the temporary defect management area and the temporary finalized defect management area, and simultaneously recorded as final defect information DFL and final defect

management information DDS (operation 1315). The final defect information DFL and the final defect management information DDS can be repeatedly recorded several times in the defect management area, in order to improve the reliability of data detection.

[Effect of the Invention]

As described above, the present invention provides a disc defect management method that is applicable to write once discs. By forming a temporary defect management area and a temporary finalized defect management area in a lead-in area and/or a lead-out area, recording defect information in such a manner that the defect information corresponds to a recording operation, finalizing defect information recorded in the temporary defect management area and recording the finalized defect information in the temporary finalized defect management area if a predetermined number of pieces of defect information is recorded in the temporary defect management area, and recording location information which next defect information will be recorded in the temporary finalized defect management area, defect information can be more rapidly read even before finalizing. Furthermore, by temporary all temporary defect information recorded in the temporary defect management area and the temporary finalized defect management area and simultaneously recording the all temporary defect information in a defect management area, when finalizing, it is possible to more effectively use the defect management area. Accordingly, in the case of a write once disc, by performing defect management while recording user data, it is possible to stably perform a backup operation without any interruption.

What is claimed is:

1. A write once disc with at least one record layer on which a lead-in area, a data area, and a lead-out area are sequentially arranged, the write once disc comprising:

a defect management area formed on at least one of the lead-in area and the lead-out area;

a temporary defect management area formed on at least one of the lead-in area and the lead-out area; and

a temporary finalized defect management area formed on at least one of the lead-in area and the lead-out area,

wherein the temporary defect management area is an area in which temporary defect information including only information regarding disc defects generated in the corresponding recording operation, and temporary defect management information including information for managing the temporary defect information are recorded, and the temporary defect information and the temporary defect management information are recorded in predetermined units as pairs of information,

the temporary finalized defect management area is an area in which temporary finalized defect information including at least one of temporary defect information recorded in the temporary defect management area, and temporary finalized defect management information including information for managing the temporary finalized defect information are recorded, and

the defect management area is an area in which the recorded temporary defect information and temporary defect management information are respectively recorded as defect information and defect management information, when finalizing.

2. The write once disc of claim 1, wherein the temporary finalized management information is recorded whenever the temporary management information is recorded k times, wherein k is an integer equal to or greater than 2.

3. The write once disc of claim 2, wherein the temporary finalized management information is obtained on the basis of temporary management information recorded when a target recording time reaches, wherein k is an integer equal to or greater than 2.

4. The write once disc of claim 3, wherein the temporary finalized management information comprises all temporary defect information constructing the temporary management information recorded when the target recording time reaches.

5. The write once disc of claim 2, wherein a plurality of defect management areas are provided.

6. The write once disc of claim 1, wherein the temporary management information includes the temporary defect informant and the temporary defect management information, and the temporary defect informant and the temporary defect management information are recorded as a pair of information to be adjacent to each other in the temporary defect management area.

7. The write once disc of claim 6, wherein the temporary defect information and temporary defect management information are recorded several times, and the temporary defect management information includes information regarding the location of corresponding temporary defect information.

8. The write once disc of claim 6, wherein the temporary defect information includes a pointer pointing out to the location of a defect and a pointer pointing out to the location of a replacement for the defect.

9. The write once disc of claim 7, wherein the temporary defect management area includes a plurality of areas, and the temporary defect information and the

temporary defect management information are respectively recorded several times in the plurality of areas.

10. A method of managing disc defects, the method comprising:

(a) recording only information regarding a defect detected in data, which is recorded in a data area of a disc during a first recording operation, as first temporary defect information in a temporary defect management area;

(b) repeating (a) and (b) at least once while increasing indexes given to the recording operation and the temporary management information by 1;

(c) recording temporary management information obtained on the basis of the recorded temporary management information whenever the first temporary management information is recorded k times, in a temporary finalized defect management area;

(d) repeating (a) through (c) at least once; and

(e) reading and writing all of recorded temporary defect management information and temporary defect information in a defect management area (k is an integer equal to or greater than 2).

11. The method of claim 10, wherein operation (e) is performed after data according to a final recording operation is recorded in the data area.

12. The method of claim 10, wherein the temporary defect management area is formed in at least one of a lead-in area and a lead-out area of the disc.

13. The method of claim 10, wherein the temporary finalized defect management area is formed in at least one of a lead-in area and a lead-out area of the disc.

14. The method of claim 10, wherein the defect management area is formed

in at least one of a lead-in area and a lead-out area of the disc.

15. The method of claim 10, wherein operation (a) comprises sequentially recording the temporary defect information and the temporary defect management information as pairs of information to be adjacent to each other, starting from the start of the temporary defect management area.

16. The method of claim 15, wherein operation (a) comprises repeatedly recording the temporary defect information and the temporary defect management information several times, and recording location information of temporary defect information corresponding to each temporary defect management information and location information of temporary defect information recorded just before the temporary defect management information, in the temporary defect management information.

17. The method of claim 16, wherein the temporary management information includes temporary defect information and temporary defect management information, and operation (a) comprises sequentially recording the temporary defect information and the temporary defect management information as pairs of information to be adjacent to each other, starting from the end of the temporary defect management area.

18. The method of claim 10, wherein the temporary management information includes temporary defect information and temporary defect management information, and operation (a) comprises sequentially recording the temporary defect information and the temporary defect management information as pairs of information to be adjacent to each other, starting from the end of the temporary defect management area.

19. The method of claim 18, wherein operation (a) comprises repeatedly recording the temporary defect information and the temporary defect management

information several times.

20. The method of claim 19, wherein the temporary defect management area includes a plurality of areas, and

operation (a) comprises repeatedly recording the temporary defect information and the temporary defect management information several times, in the plurality of areas.

21. The method of claim 19, wherein operation (a) comprises repeatedly recording the temporary defect information and the temporary defect management information several times, and recording location information of temporary defect information corresponding to each temporary defect management information and location information of temporary defect information recorded just before the temporary defect management information, in the temporary defect management information.

22. The method of claim10, wherein operation (a) comprises:

(a1) recording data in a predetermined unit of data;

(a2) verifying the recorded data to detect a part in which a defect is found;

(a3) storing defective area information indicating the part in which the defect is found, and information indicating a substitution area for substituting for the part in which the defect is found, as temporary defect information, in a memory;

(a4) repeating operation (a1) through (a3) at least one time; and

(a5) if the recording operation is terminated, reading the information stored in the memory and recording the temporary defect information and temporary defect management information for managing the temporary defect information, in units of a predetermined number of blocks, in the temporary defect management area.

23. A recording apparatus comprising:

a recording/reading unit that records data on or reads data from a disc; and

a controller that controls the recording/reading unit to record temporary defect information regarding a defect detected from data, which is recorded in a data area of the disc according to a recording operation, and temporary management information including the temporary defect management information, in units of a predetermined number of blocks, in a temporary defect management area, and to record temporary finalized management information obtained on the basis of the temporary defect management information recorded in the temporary defect management area whenever the temporary management information is recorded k times, in a temporary finalized defect management area, wherein k is an integer equal to or greater than 2.

24. The recording apparatus of claim 21, wherein the controller controls the recording/reading unit in such a manner that the temporary defect information and the temporary defect management information constructing the temporary management information are recorded as pairs of information to be adjacent to each other.

25. The recording apparatus of claim 21, wherein the controller controls the recording/reading unit so that location information of temporary defect information corresponding to the temporary management information and location information of temporary defect information recorded just before the corresponding temporary defect information are recorded.

26. The recording apparatus of claim 21, wherein the controller controls the recording/reading unit so that the recording/reading unit records the temporary management information in the temporary defect management area whenever a recording operation is performed, and records defect information and defect management information obtained on the basis of the recorded temporary management information and temporary finalized management information, in a defect management area, when finalizing.

27. The recording apparatus of claim 21, wherein the temporary defect management area includes a plurality of areas, and

the controller controls the recording/reading unit to repeatedly record the temporary management information several times, in the plurality of areas.

FIG. 1

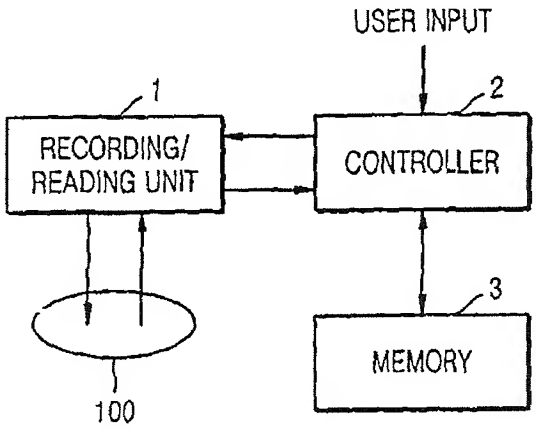
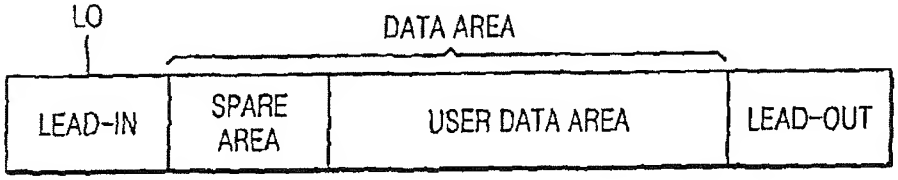
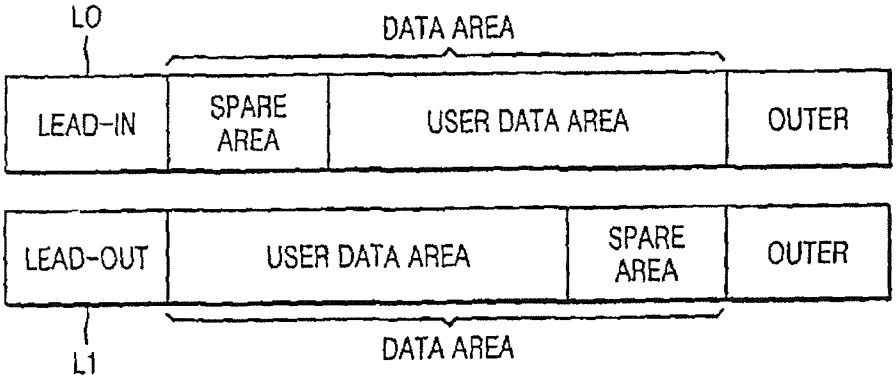

USER INPUT
1
2
RECORDING/
READING UNIT
CONTROLLER
3
MEMORY
100

FIG. 2


LO
DATA AREA
LEAD-IN
SPARE AREA
USER DATA AREA
LEAD-OUT

(a)


LO
DATA AREA
LEAD-IN
SPARE AREA
USER DATA AREA
OUTER
LEAD-OUT
USER DATA AREA
SPARE AREA
OUTER
L1
DATA AREA

(b)

FIG. 3A

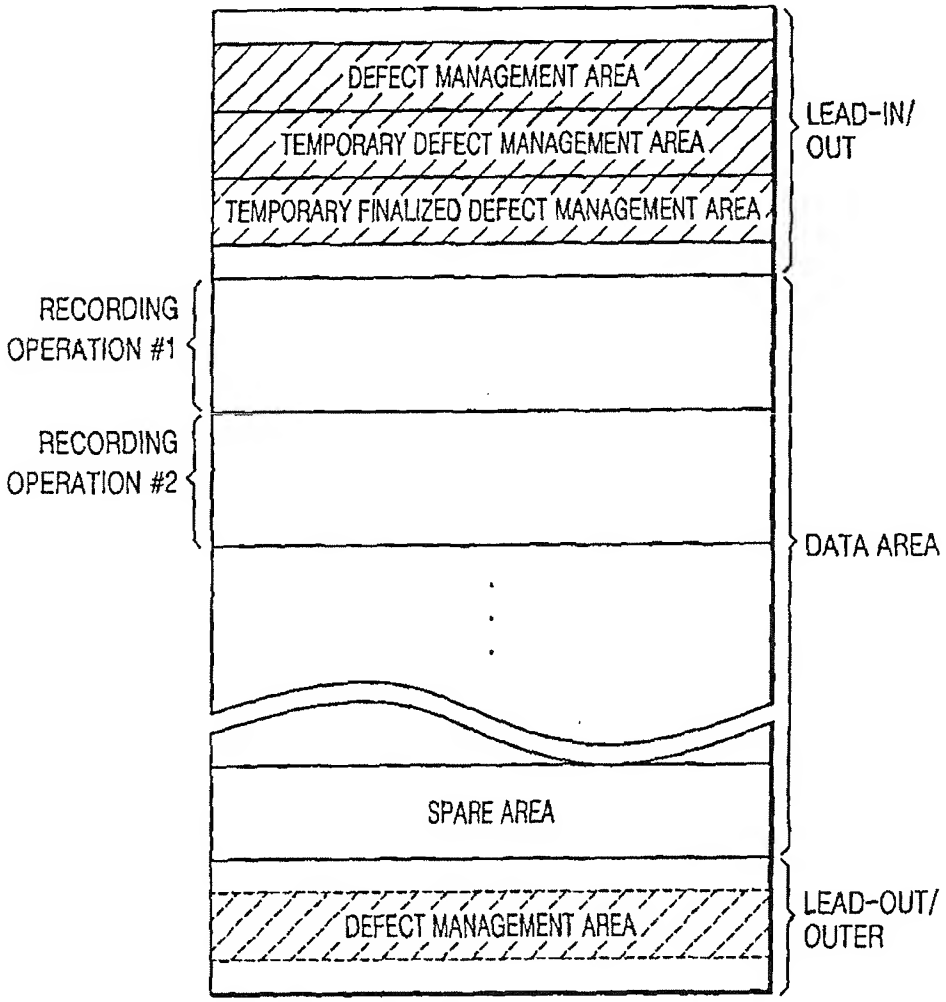

DEFECT MANAGEMENT AREA
TEMPORARY DEFECT MANAGEMENT AREA
TEMPORARY FINALIZED DEFECT MANAGEMENT AREA
LEAD-IN/ OUT
RECORDING OPERATION #1
RECORDING OPERATION #2
DATA AREA
SPARE AREA
DEFECT MANAGEMENT AREA
LEAD-OUT/ OUTER

FIG. 3B

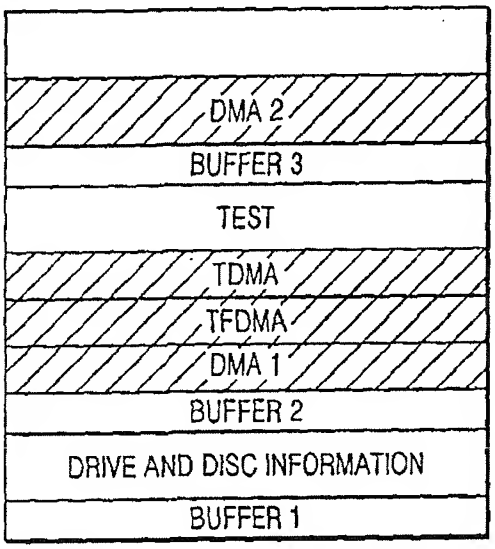

DMA 2
BUFFER 3
TEST
TDMA
TFDMA
DMA 1
BUFFER 2
DRIVE AND DISC INFORMATION
BUFFER 1

FIG. 4

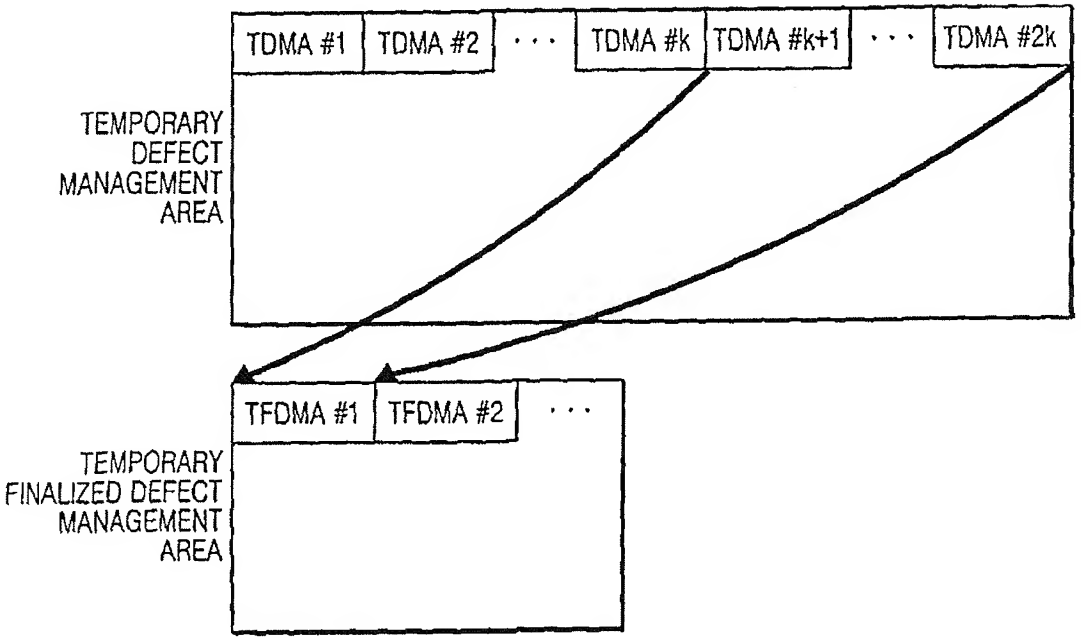

TDMA #1
TDMA #2
TDMA #k
TDMA #k+1
TDMA #2k
TEMPORARY DEFECT MANAGEMENT AREA
TFDMA #1
TFDMA #2
TEMPORARY FINALIZED DEFECT MANAGEMENT AREA

FIG. 5A

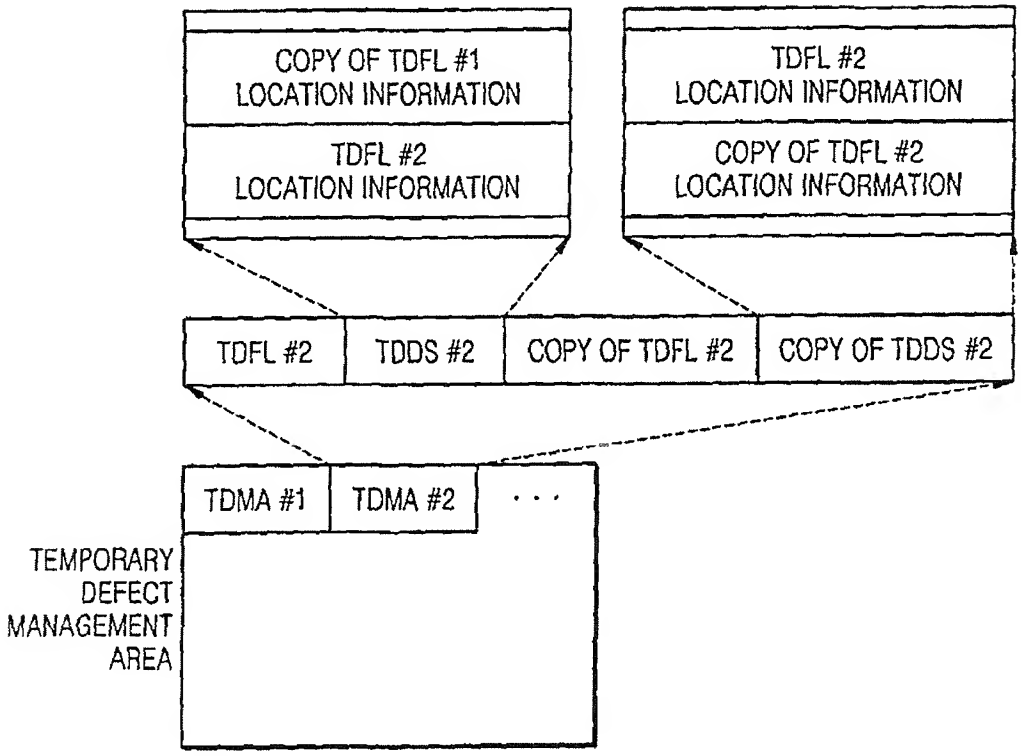

COPY OF TDFL #1
LOCATION INFORMATION
TDFL #2
LOCATION INFORMATION
TDFL #2
LOCATION INFORMATION
COPY OF TDFL #2
LOCATION INFORMATION
TDFL #2
TDDS #2
COPY OF TDFL #2
COPY OF TDDS #2
TDMA #1
TDMA #2
. . .
TEMPORARY
DEFECT
MANAGEMENT
AREA

FIG. 5B

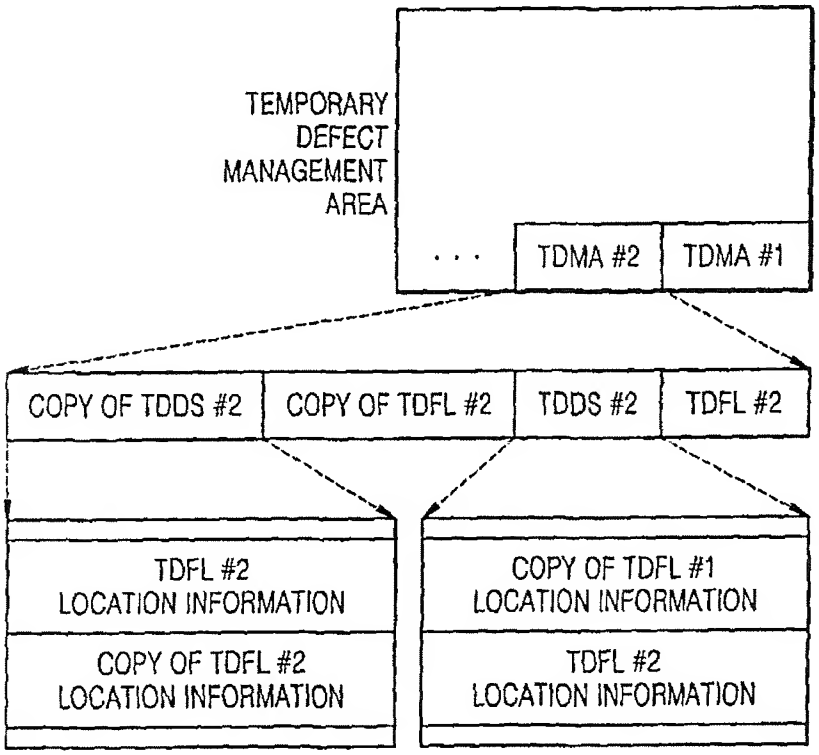

TEMPORARY DEFECT MANAGEMENT AREA
. . .
TDMA #2
TDMA #1
COPY OF TDDS #2
COPY OF TDFL #2
TDDS #2
TDFL #2
TDFL #2 LOCATION INFORMATION
COPY OF TDFL #2 LOCATION INFORMATION
COPY OF TDFL #1 LOCATION INFORMATION
TDFL #2 LOCATION INFORMATION

FIG. 5C

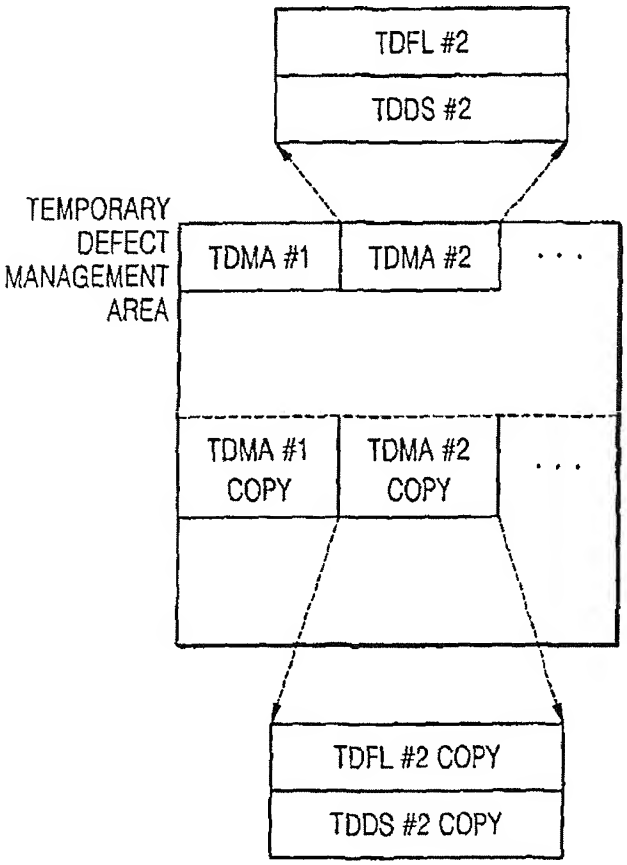

TDFL #2
TDDS #2
TEMPORARY DEFECT MANAGEMENT AREA
TDMA #1
TDMA #2
. . .
TDMA #1 COPY
TDMA #2 COPY
. . .
TDFL #2 COPY
TDDS #2 COPY

FIG. 6A

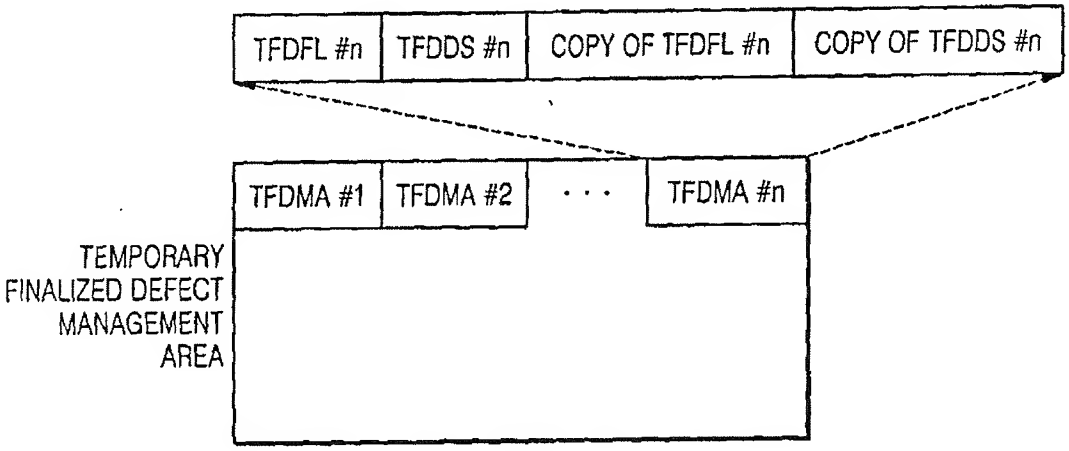

TFDFL #n
TFDDS #n
COPY OF TFDFL #n
COPY OF TFDDS #n
TFDMA #1
TFDMA #2
TFDMA #n
TEMPORARY FINALIZED DEFECT MANAGEMENT AREA

FIG. 6B

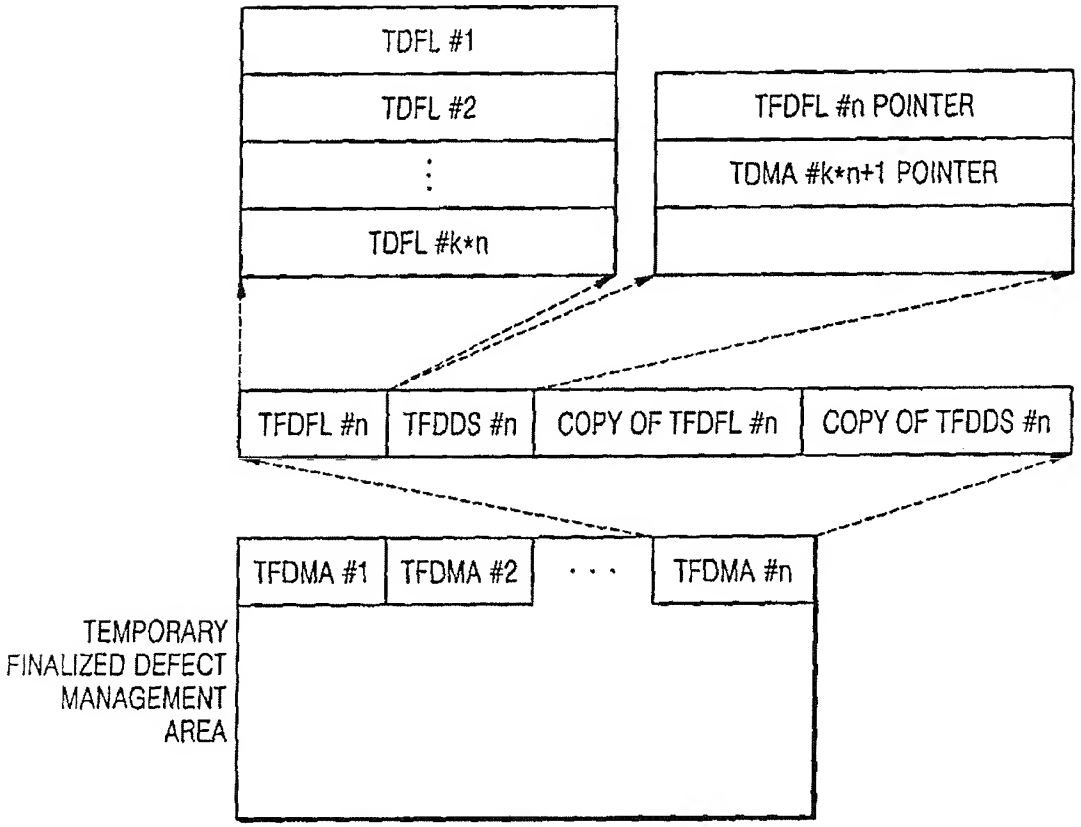

TDFL #1
TDFL #2
TDFL #k*n
TFDFL #n POINTER
TDMA #k*n+1 POINTER
TFDFL #n
TFDDS #n
COPY OF TFDFL #n
COPY OF TFDDS #n
TFDMA #1
TFDMA #2
TFDMA #n
TEMPORARY FINALIZED DEFECT MANAGEMENT AREA

FIG. 6C

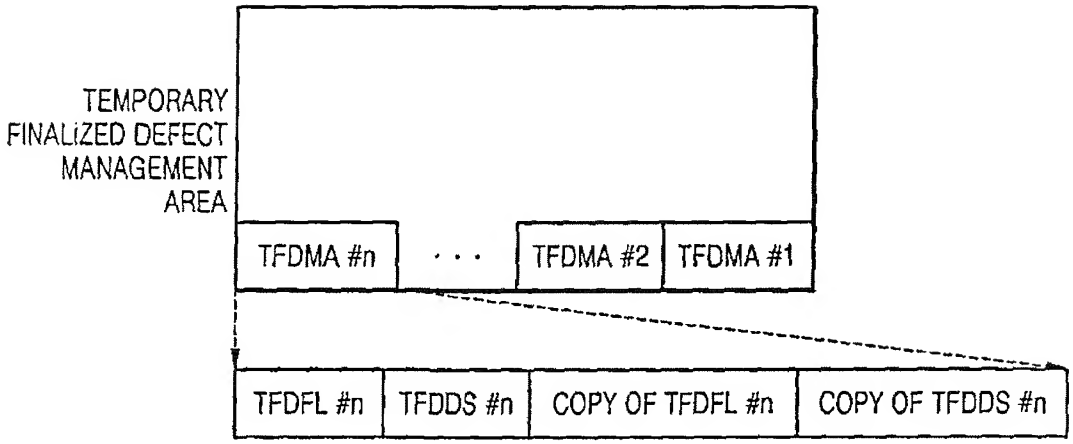

TEMPORARY FINALIZED DEFECT MANAGEMENT AREA
TFDMA #n
. . .
TFDMA #2
TFDMA #1
TFDFL #n
TFDDS #n
COPY OF TFDFL #n
COPY OF TFDDS #n

FIG. 6D

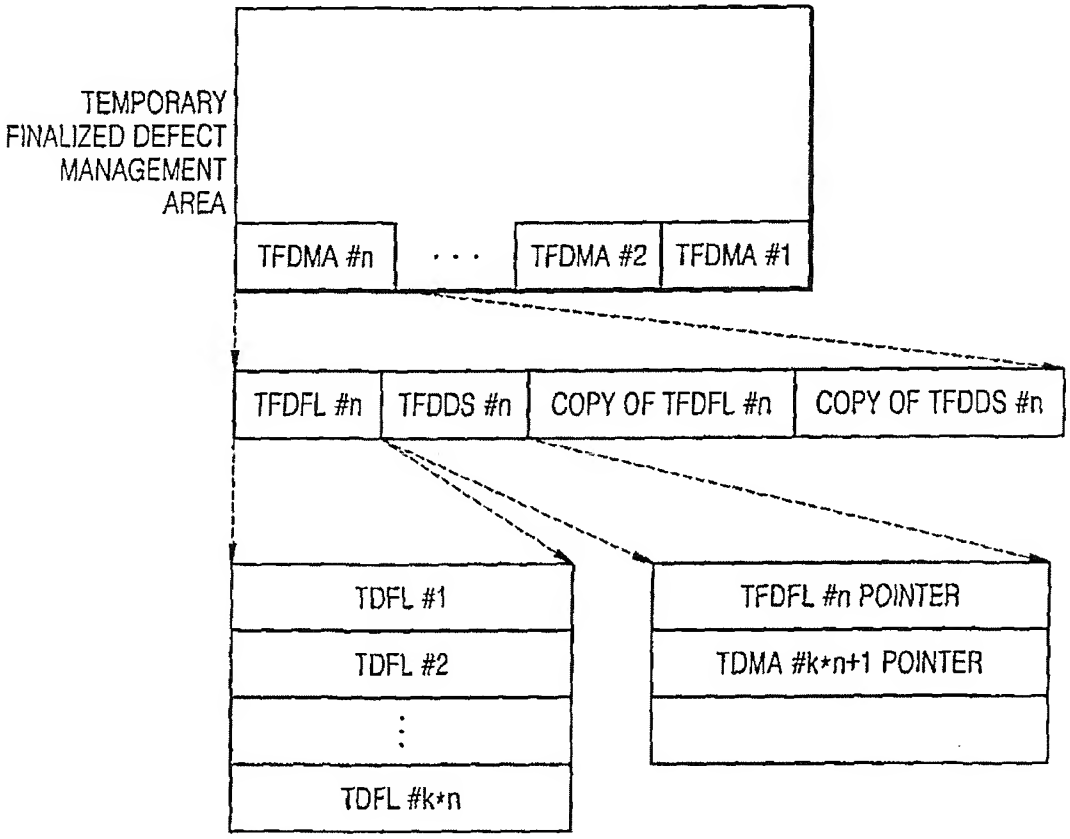

TEMPORARY FINALIZED DEFECT MANAGEMENT AREA
TFDMA #n
TFDMA #2
TFDMA #1
TFDFL #n
TFDDS #n
COPY OF TFDFL #n
COPY OF TFDDS #n
TDFL #1
TDFL #2
TDFL #k*n
TFDFL #n POINTER
TDMA #k*n+1 POINTER

FIG. 7A

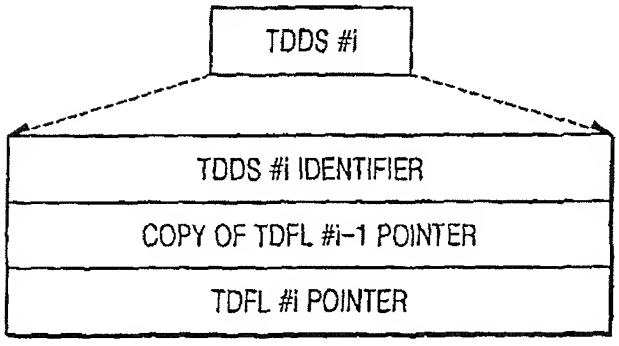

TDDS #i
TDDS #i IDENTIFIER
COPY OF TDFL #i-1 POINTER
TDFL #i POINTER

FIG. 7B

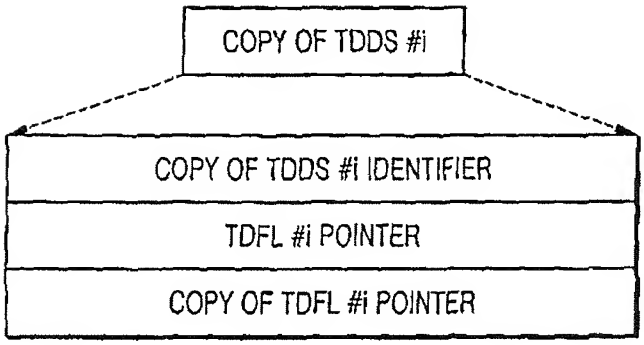

COPY OF TDDS #i
COPY OF TDDS #i IDENTIFIER
TDFL #i POINTER
COPY OF TDFL #i POINTER

FIG. 8

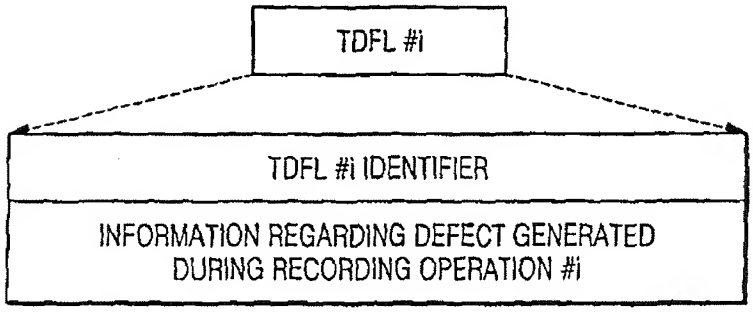

TDFL #i
TDFL #i IDENTIFIER
INFORMATION REGARDING DEFECT GENERATED DURING RECORDING OPERATION #i

FIG. 9

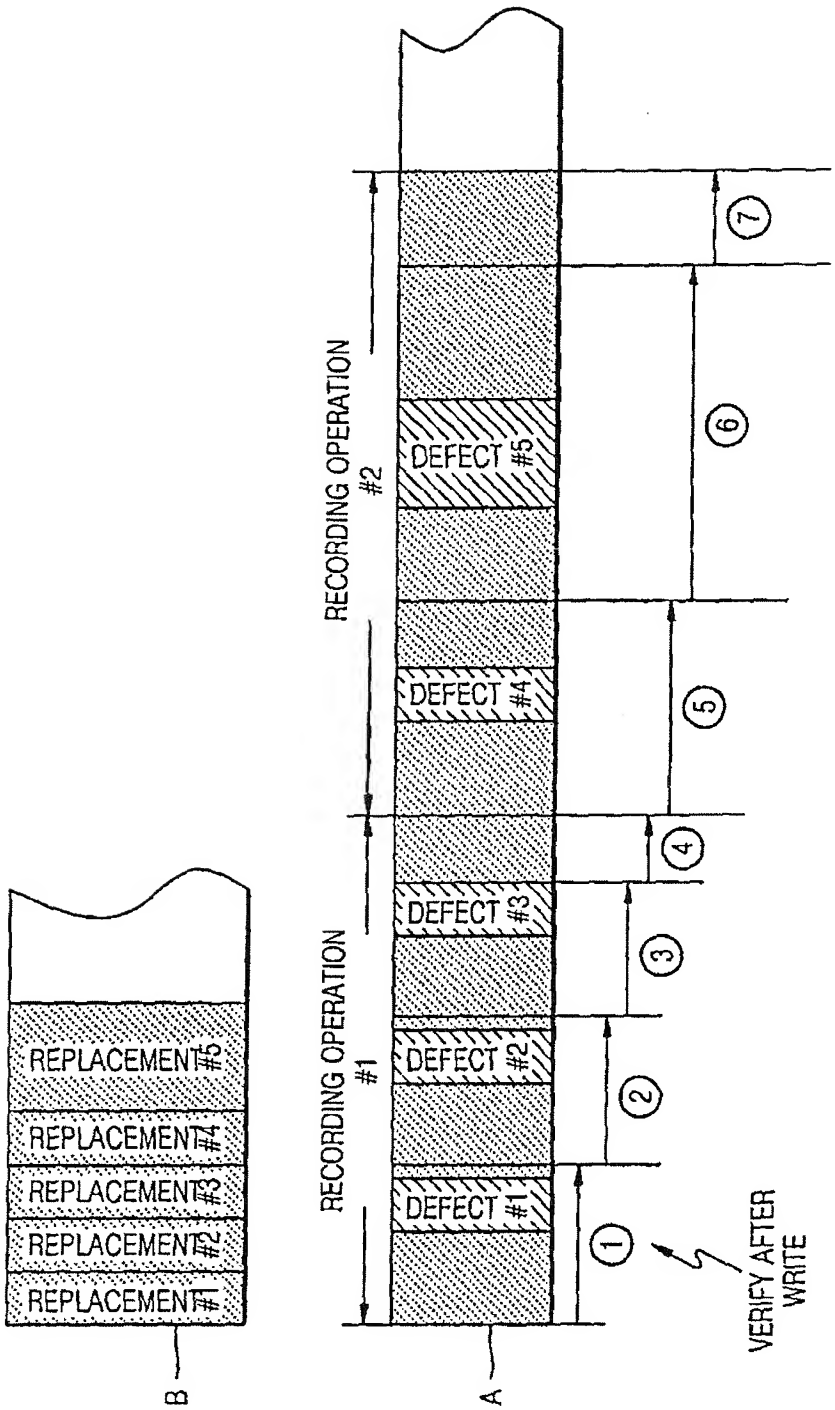
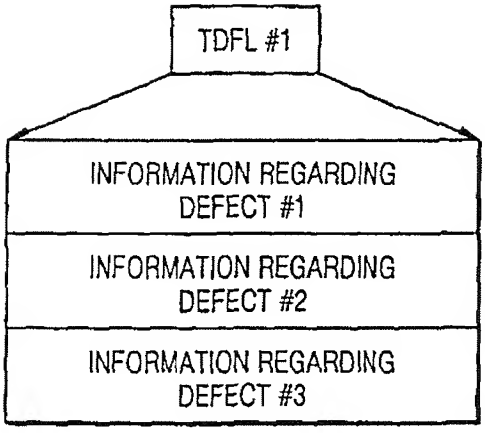
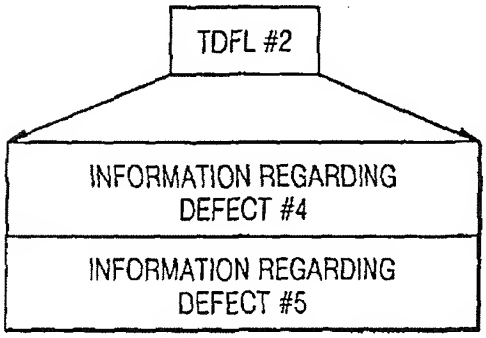

REPLACEMENT #5
REPLACEMENT #4
REPLACEMENT #3
REPLACEMENT #2
REPLACEMENT #1
B
A
RECORDING OPERATION #1
RECORDING OPERATION #2
DEFECT #1
DEFECT #2
DEFECT #3
DEFECT #4
DEFECT #5
1
2
3
4
5
6
7
VERIFY AFTER WRITE

FIG. 10



(a)



(b)

FIG. 11

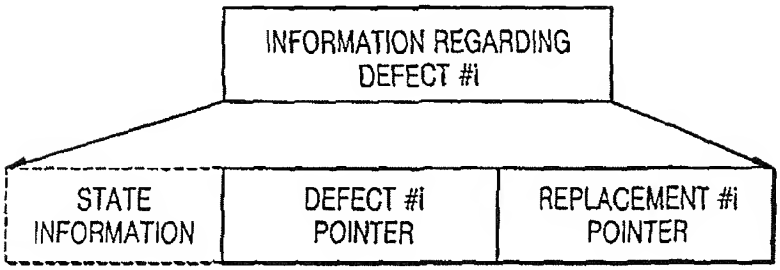


FIG. 12

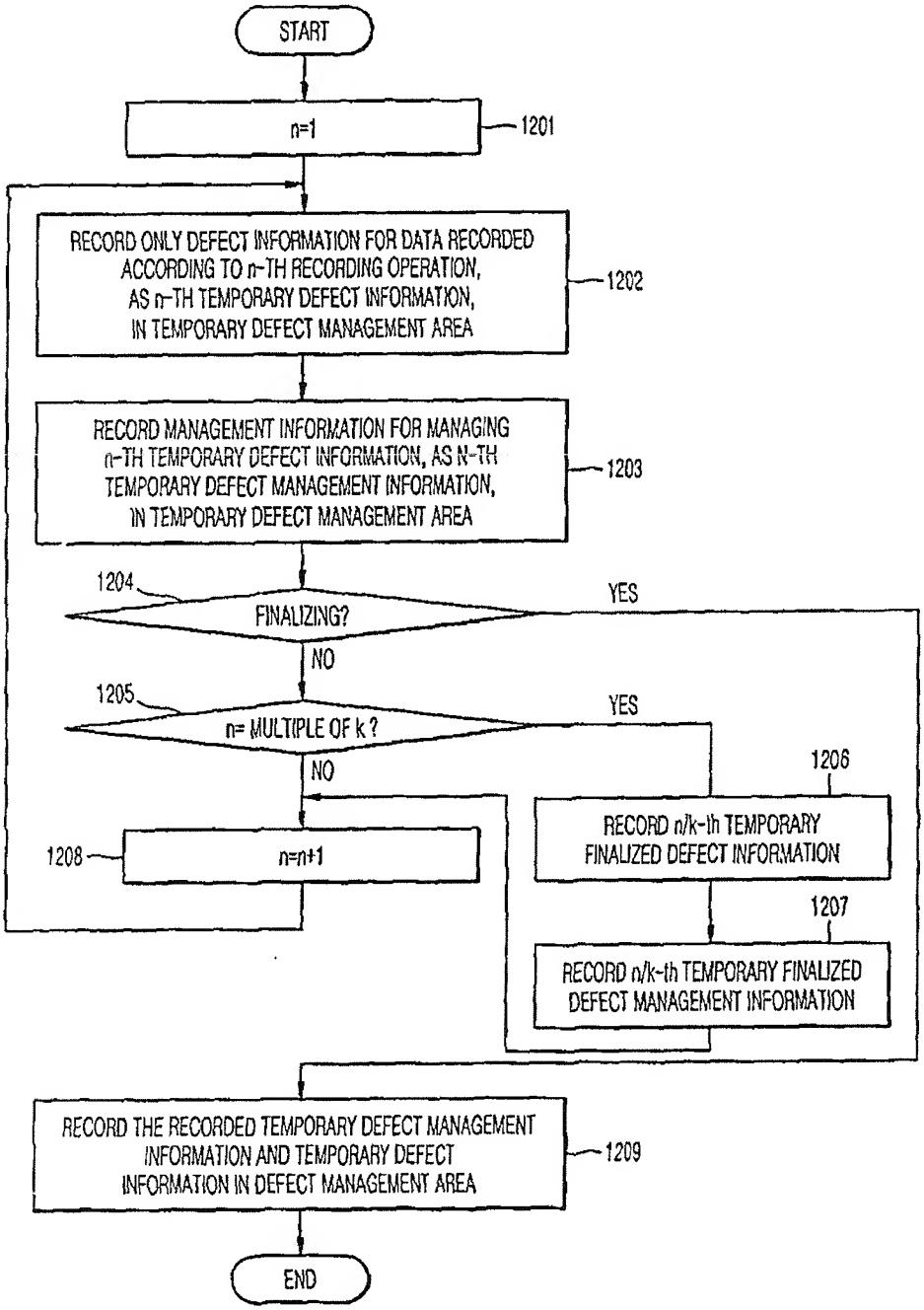
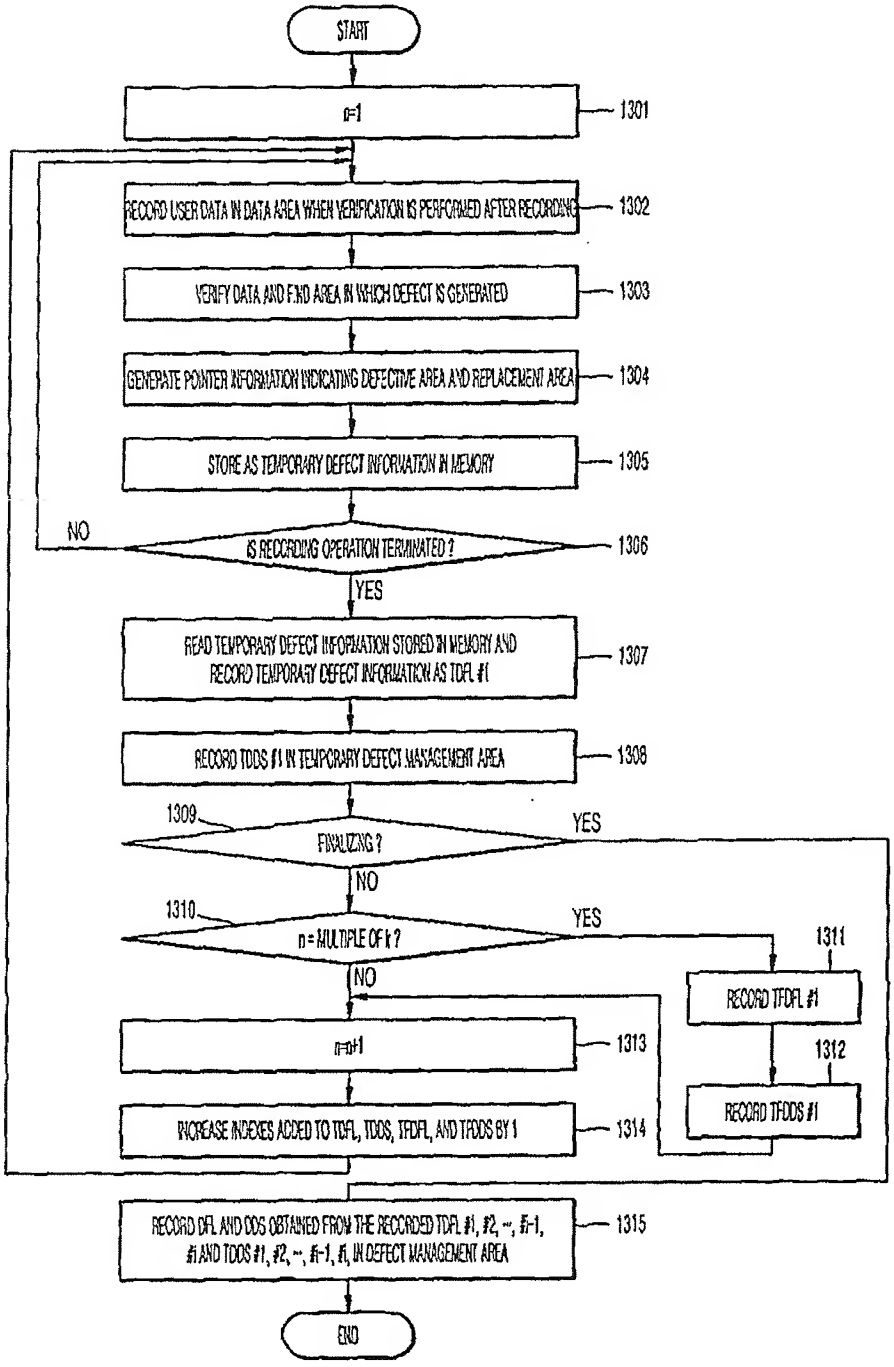

START
n=1
1201
RECORD ONLY DEFECT INFORMATION FOR DATA RECORDED ACCORDING TO n-TH RECORDING OPERATION, AS n-TH TEMPORARY DEFECT INFORMATION, IN TEMPORARY DEFECT MANAGEMENT AREA
1202
RECORD MANAGEMENT INFORMATION FOR MANAGING n-TH TEMPORARY DEFECT INFORMATION, AS N-TH TEMPORARY DEFECT MANAGEMENT INFORMATION, IN TEMPORARY DEFECT MANAGEMENT AREA
1203
1204
FINALIZING?
YES
NO
1205
n= MULTIPLE OF k ?
YES
NO
1206
RECORD n/k-th TEMPORARY FINALIZED DEFECT INFORMATION
1207
RECORD n/k-th TEMPORARY FINALIZED DEFECT MANAGEMENT INFORMATION
1208
n=n+1
RECORD THE RECORDED TEMPORARY DEFECT MANAGEMENT INFORMATION AND TEMPORARY DEFECT INFORMATION IN DEFECT MANAGEMENT AREA
1209
END

FIG. 13


START
n=1
1301
RECORD USER DATA IN DATA AREA WHEN VERIFICATION IS PERFORMED AFTER RECORDING
1302
VERIFY DATA AND FIND AREA IN WHICH DEFECT IS GENERATED
1303
GENERATE POINTER INFORMATION INDICATING DEFECTIVE AREA AND REPLACEMENT AREA
1304
STORE AS TEMPORARY DEFECT INFORMATION IN MEMORY
1305
NO
IS RECORDING OPERATION TERMINATED ?
1306
YES
READ TEMPORARY DEFECT INFORMATION STORED IN MEMORY AND RECORD TEMPORARY DEFECT INFORMATION AS TDFL #1
1307
RECORD TDDS #1 IN TEMPORARY DEFECT MANAGEMENT AREA
1308
1309
FINALIZING ?
YES
NO
1310
n = MULTIPLE OF k ?
YES
1311
RECORD TFDFL #1
NO
n=n+1
1313
1312
RECORD TFDDS #1
INCREASE INDEXES ADDED TO TDFL, TDDS, TFDFL, AND TFDDS BY 1
1314
RECORD DFL AND DDS OBTAINED FROM THE RECORDED TDFL #1, #2, ··, #i-1, #i AND TDDS #1, #2, ··, #i-1, #i, IN DEFECT MANAGEMENT AREA
1315
END